# LABORATORY RESULTS ON AMMONIA REMOVAL FROM FLY ASH USING an ACOUSTICALLY ENHANCED FLUIDIZED BED

Edward K. Levy and Kenneth B. Lawton
Energy Research Center, Lehigh University, 117 ATLSS Drive, Bethlehem, Pennsylvania 18015
E-mail: ekl0@lehigh. edu; Telephone: (610) 758-4090; Fax: (610) 758-5959

## Summary

This paper deals with the development of a dry process to remove ammonia from fly ash. The process involves use of a fluidized bed in which ash is fluidized with air and heated to decompose the ammonium compounds. Fly ash is typically difficult to fluidize because of the small size of the particles. This approach makes use of acoustics to promote active bubbling and improve the fluidization characteristics of the ash.

At the 2001 DOE NETL Conference on SNCR/SCR, we presented laboratory data on the bed process conditions required to accomplish ammonia removal. Those experiments were performed in a batch fluidized bed on ashes from three different power plants. Those ashes had initial ammonia concentrations ranging from 500 to 1100 ppm. The experiments were performed by loading room temperature ash into the bed, fluidizing and heating the ash, and then periodically removing samples of ash and analyzing the ash for ammonia content. The results show sharp reductions in ammonia began to occur at 500°F, with almost all of the ammonia removed with ash temperatures in the 675 to 750°F range.

The present paper deals with a system for continuous processing of ash. Referred to as an inclined fluidized bed, this system heats the ash as the fluidized ash flows along the surface of the distributor. Ash is fed to the bed at one end, ammonia is removed with the fluidizing air and ammonia-free ash is removed from the far end of the bed.

The apparatus used for the present experiments was designed to operate with continuous ash feed and removal, at a maximum ash flow rate of 500 lbm/hr. The bed vessel is 6" wide and 20 ft long. It has loud speakers positioned above the distributor to promote bubbling fluidization of the ash. The loud speakers are powered by a signal generator and an amplifier. Air is used as fluidizing gas at a flow rate of approximately 60 scfm.

Electrical immersion heaters located in the bed are used to heat the ash to the temperatures needed to drive off the ammonia. Before discharging from the bed, the ash flows through an air-cooled tubular heat exchanger for recovery of sensible heat from the ash. The entire bed vessel, including speakers, is enclosed to prevent exposure of operators to unsafe sound pressure levels. The exhaust gas from the ash processing unit is ducted to a filter for removal of entrained ash.

The system is instrumented with thermocouples for measurement of ash temperatures and flow meters for measurement of air flow rates. Sound pressure levels within the bed vessel are measured using a sound meter.

The concentrations of $NH_3$ in the ash feed stream and in the ash discharge were determined by obtaining grab samples of ash and using an Ammonia Ion Selective Electrode to measure ammonia content. The procedure requires a sample of ash be placed in a sulfuric acid solution. The ammonium compounds in the ash dissolve, making it possible for the ammonia electrode to detect the ammonia levels.

The ash used in these experiments had ammonia concentrations of approximately 1100 ppm. The data described below were obtained in an experiment in which room temperature ash was fed to the, initially empty, bed, causing the section with the electric heaters to become filled with ash. This was done with fluidizing air turned on and with the speakers energized. The power to the electrical heaters was then turned on, causing the ash in the heated section to increase in temperature. Ash samples, collected at the discharge end of the bed, were weighed to determine ash flow rate. The experiment was conducted with three ash feeder speeds, resulting in ash discharge rates of 75, 180 and 325 #/hr. Temperature and flow rate data were collected over a 3 hour period, with ash samples also collected for ammonia analysis. Tests were also performed in the batch bed with the same fly ash under similar process conditions.

The results show the percentage ammonia removal ranged from 96 percent at a peak ash temperature of 725°F to 35 percent at a peak ash temperature of 545°F. The results also show close agreement between the performance of the batch bed and the continuously operating bed. This indicates that with this design, ammonia removal depends primarily on ash temperature. The ash residence times in the hot end of the heated section are apparently long enough so that residence time wasn't a factor in removing ammonia. The results also suggest that there are no problems with this design associated with flow patterns of ash or ash stratification which would lead to lower than expected $NH_3$ removal efficiencies.

In the next phase of this program, we propose to expand the operating range of the apparatus to higher flow rates, test other fly ashes to determine the ability to the system to handle ashes with different properties, and test the system at a power plant with a small stream of ash taken directly from the ESP or ash silo. Finally, we plan to develop a design for a commercial scale system and estimate equipment and operating and maintenance costs.